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SG 00/00114
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Date of Filing	:	10 AUG 1999
Application number	:	PCT/SG99/00082
Applicants	:	NANYANG TECHNOLOGICAL UNIVERSITY
Title of Invention	:	A FINGERPRINT SENSING DEVICE

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5 SEP 2000

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PCT/SG [redacted]00082

International Application No.

10 AUGUST 1999

International Filing Date (10-08-99)

REGISTRY OF PATENTS (SINGAPORE)
PCT INTERNATIONAL APPLICATION

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* FP1168

Box No. I TITLE OF INVENTION

A Fingerprint Sensing Device

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

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Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

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- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

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This person is:
- ☐ applicant only
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State *(that is, country)* of nationality:

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Regional Patent

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Box No. VI PRIORITY CL[redacted] ☐ Further priority [redacted]dicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	[redacted]mber of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1)				
item (2)				
item (3)				

☐ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s):

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Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):*

ISA / AT

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

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Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following number of sheets:

request	:	4
description (excluding sequence listing part)	:	10
claims	:	3
abstract	:	1
drawings	:	2
sequence listing part of description	:	
Total number of sheets	:	20

This international application is accompanied by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
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9. ☒ other *(specify)*: PF48

Figure of the drawings which should accompany the abstract: 1

Language of filing of the international application: English

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

MCCALLUM, GRAEME DAVID
AGENTS FOR THE APPLICANTS

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1. Date of actual receipt of the purported international application: 10 AUGUST 1999 (10-08-99)
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
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A FINGERPRINT SENSING DEVICE

The invention relates to a fingerprint sensing device, and especially, a solid state fingerprint sensing device.

Solid state fingerprint sensors are produced on a single semiconductor chip (or die) and comprise an array of sensing elements, such as capacitive sensors or electric field sensors, formed in a two dimensional array on the surface of the die.

However, this fabrication technique has the disadvantage that the die must have a surface area which is at least the same size as the fingerprint sensing area. As, the fingerprint sensing area must be large enough to accommodate the fingerprint of a user, the fingerprint sensing area must generally be at least 10mm x 10mm. If the fingerprint sensing area is much smaller than this then the area will be too small to permit the fingerprint of a user to be captured. Preferably, the fingerprint sensing area should be a larger size.

This creates a problem with die fabrication as the larger the die is the higher the probability that the die will have an error or fault. Therefore, as the die size increases, the probability of having a die in a batch with an error increases and therefore the yield of operable dies from a batch decreases. For this reason, the larger a fingerprint sensor is, the more expensive it is and the

increase in cost is driven not only by the increase size, and therefore the increase in material in the die, but also the lower yield from a batch.

In addition, the requirement for larger dies also reduces the efficiency with which the silicon wafer surface area can be utilised as less dies can be fitted on the surface of the wafer. This also has the disadvantage of increasing the cost of solid state fingerprint sensors.

In accordance with a first aspect of the present invention, a fingerprint sensing device comprises a number of fingerprint sensor dies, each die comprising a sensing array surface, the dies being arranged so that the sensing array surfaces of the dies define a device sensing surface.

An advantage of the invention is that as the fingerprint sensing device is formed from a number of fingerprint sensor dies, the sensing area of the fingerprint sensing device is not restricted to the surface area of one die on which a fingerprint sensor array is formed as the sensing surface of the fingerprint sensing device can be increased or decreased by using an appropriate number of fingerprint sensor dies. Therefore, fingerprint sensor dies with a relatively small sensing array surface can be used to form a fingerprint sensing device with a relatively large device sensing surface.

Typically, the device sensing surface is substantially

planar.

In one example of the invention, the sensing array surfaces may be arranged in a one dimensional array. This arrangement is particularly useful where the length of the sensing array surface of each die is relatively large compared with the width.

Alternatively, the dies arranged so that the sensing array surfaces form a two dimensional array. This arrangement is particularly useful where the width and length of the sensing array surfaces are of a similar size.

Preferably, each sensing array surface is less than 15mm x 15mm and more preferably, less than 10mm x 10mm.

Typically, the fingerprint sensing device may further comprise a ground contact located between the sensing array surfaces of two adjacent fingerprint sensor dies. Preferably, the ground contact may be located between each pair of adjacent sensing array surfaces of the fingerprint sensor dies.

In one example of the invention, the ground contact may be in the form of a grid with a conducting surface which is raised above the surface of the sensing array surfaces. This has the advantage that when a user places a finger on the device sensing surface, the risk of the fingerprint touching a sensing surface before touching the grid is

minimised so that any static charge on the user is discharged through the ground contact and not onto one of the fingerprint sensor dies. This has the advantage of minimising the possibility of a user carrying a static charge damaging the sensing device by a static discharge onto one or more of the sensing array surfaces.

In accordance with a second aspect of the present invention, there is provided a method of constructing a fingerprint image, the method comprising obtaining a number of fingerprint image portions from a finger of a user using a fingerprint sensing device in accordance with the first aspect of the invention, each image portion being obtained from a corresponding sensor die, calculating direction information at an edge of a first image portion corresponding to an edge of a first sensing array surface which is adjacent to but separated from an edge of a second sensing array surface, interpolating the direction information and pixel values at the edge of the first image portion to obtain the values of pixels between the edge of the first image portion and an edge of a second image portion corresponding to the edge of the second sensing array surface.

Preferably, the method further comprises calculating direction information at the edge of the second image portion and interpolating the direction information and the pixel values at the edges of the first and second image

portions to obtain the values of pixels between the edges of the first and second image portions.

In accordance with a third aspect of the present invention, there is provided a method of constructing a fingerprint image, the method comprising obtaining a first set of fingerprint image portions from a finger of a user using a fingerprint sensing device according to the first aspect of the invention, each image portion being obtained from a corresponding sensor die, obtaining a second set of fingerprint image portions from the fingerprint sensing device with the position of the finger on the sensing device offset from the position in which the first set of image portions was obtained, and comparing the first and the second sets of fingerprint image portions.

An example of a fingerprint sensing device in accordance with the invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 shows a plan view of a device sensing surface of a fingerprint sensing device with fingerprint sensor dies arranged in a one dimensional array;
Figure 2 is a plan view of a device sensing surface of a fingerprint sensing device with fingerprint sensor dies arranged in a two dimensional array; and
Figure 3 shows a portion of two fingerprint image portions obtained using the device shown in Figure 1 or Figure 2.

Figure 1 shows a fingerprint sensing device 10 which comprises four individual fingerprint sensor dies 11 arranged in a one dimensional linear array. Each of the fingerprint sensor dies 11 has a sensing array surface 12. Each of the fingerprint sensor dies 11 is a conventional solid-state fingerprint sensor, such as a direct contact, fingerprint acquisition device using capacitive sensing. This type of device has an array of solid-state capacitors formed on surface 12. A typical, commercially available, solid state fingerprint sensing device that could be used for the fingerprint sensor dies 11 is a Veridicom FPS100 produced by Veridicom, Inc. of Santa Clara, California, USA.

Each of the fingerprint sensor dies 11 has an individual controller (not shown) formed on the die and all the individual controllers are multiplexed to a main central sensor controller (not shown) for the sensing device 10. The central sensor controller may also include a sensor oscillator (not shown) which can be used to ensure synchronisation of the individual sensor dies 11.

As an alternative to the dies 11 comprising an array of capacitive sensors, it is possible that they could comprise an array of electric field sensors, or an array of any other suitable type of sensors.

The sensing device 10 also includes a metal grid plate 14 which has four apertures 13 into which the sensor dies 11

locate. The top surface of the grid plate 14 is raised above the sensing array surfaces 12 of the fingerprint sensor dies 11 and the plate 14 is electrically coupled to a ground contact (not shown).

Therefore, each of the sensing areas 12 together form a device sensing surface for the device 10. The area of the device sensing surface is the sum of the surface areas of each individual sensing array surface 12.

Figure 2 shows another fingerprint sensing device 20 which includes a metallic grid plate 21 with eight apertures 22 therein. A fingerprint sensor die 23 having a sensing array surface 24 is located in each aperture 22 so that the sensor array surfaces 24 together form a device sensing surface for the device 20. Therefore, the sensing surface for the device 20 is eight times the size of each sensing array surface 24.

As shown in Figure 2, the sensor array surfaces 24 are arranged in a two dimensional array. As with the sensor dies 11, described above and shown in Figure 1, the sensor dies 23 may be any conventional solid state fingerprint sensor using a capacitive sensing array, an electric field sensing array or any other suitable type of sensing array.

As with the metallic grid plate 12, the metallic grid plate 21 is also electrically coupled to ground and the top surfaces of the grid plate 21 are raised above the surface

areas 24.

In use, when a user, who is to have their fingerprint captured by the device 10 or the device 20, places their finger on the sensing surface, due to the presence of the metallic grid plate 14, 21, and that the surface of the grid plate 14, 21 is raised above the surface of the sensing array surfaces 12, 24, the user's finger should contact the grid plate 14, 21 before contacting the surface array surfaces 12, 24 so that any static charge on the user will be discharged through the ground plate 14, 21 rather than through one of the sensor dies 11, 23. Therefore, this feature minimises the risk of one of the sensors 11, 23 being damaged by a static discharge during use.

In the two examples described above, the ground plates 14, 21 are formed so that the respective sensors 11, 23 fit into the respective apertures 13, 22 by being inserted from below the ground plate 14, 21. However, in an alternative example, it is possible that ground contacts could be formed on a supporting base plate for the sensor dies 11, 23 so that when the sensor dies 11, 23 are fitted into the base plate, the ground contacts extend up between each individual sensor dies 11, 23 so that the upper surfaces of the ground contacts are raised above the surfaces of the sensing array surfaces 12, 24.

In use, the various images acquired from each of the individual sensor dies 11, 23 have to be assembled together

in order to construct a complete fingerprint image. However, there are gaps 15 between adjacent dies 11 and gaps 25, 26 between adjacent dies 24 corresponding to the ground plates 14, 21. Therefore, if the images from each die 12, 24 are assembled to construct the fingerprint image, there will be discontinuities or gaps 31 (see Figure 3) in the image corresponding to the gaps 15, 25, 26. The discontinuities will cause errors in the minutiae extraction process. Therefore, it is necessary to calculate pixel values 34 for the gaps 15, 25, 26 to ensure that there are no discontinuities in the final fingerprint image. Two possible ways of filling in the missing information are:

(i) Any fingerprint image is inherently directional. Therefore, direction information 33 is useful in the construction (see Figure 3). The direction information 33 can be computed easily, using various conventional image processing methods. The size of the gap 31 and the resolution of the sensor dies 11, 23 are known in advance from the specification of the sensor dies 11, 23. From the specification, the number of picture elements (pixels) in the image to be allocated for the gap 31 can be calculated. However, the actual values of the pixels 34 in the gap 31 are not known. Therefore, the pixel values 34 can be estimated by using the pixel values 32 and the direction information 33 at both edges of the gap 31 by means of interpolation;

(ii) Alternatively, the fingerprint image can be acquired twice with one of the images being slightly translated from the other in both the horizontal and vertical directions. The unknown pixel values in the separation region 31 can then be estimated from the two images using conventional image processing techniques.

Advantages of the invention are that by forming a fingerprint sensing device 10, 20 from a number of fingerprint sensor dies 11, 23, it is possible to form a fingerprint sensing device 10, 20 with a device sensing surface which is many times larger than the sensing array surface 12, 24 of each individual sensor dies 11, 23. This has the advantage that relatively small, and therefore inexpensive, sensor dies 11, 23 can be used to form a sensing device 10, 20 with a much larger sensing surface. In addition, by using a number of sensor dies 11, 23 to form the sensing devices 10, 20 it is also possible to provide an electrical ground contact grid over the device sensing surface to minimise the risk of static discharge damaging the sensor dies 11, 23 in use.

CLAIMS

1. A fingerprint sensing device comprising a number of fingerprint sensor dies, each die comprising a sensing array surface, the dies being arranged so that the sensing array surfaces of the dies define a device sensing surface.

2. A device according to claim 1, wherein the device sensing surface is substantially planar.

3. A device according to claim 1 or claim 2, wherein the dies are arranged so that the sensing array surfaces form a one dimensional array.

4. A device according to claim 1 or claim 2, wherein the dies are arranged so that the sensing array surfaces form a two dimensional array.

5. A device according to any of the preceding claims, wherein the sensing array surfaces are less than 15mm x 15mm.

6. A device according to claim 5, wherein the sensing array surfaces are less than 10mm x 10mm.

7. A device according to any of the preceding claims, further comprising a ground contact located between the sensing array surfaces of at least two adjacent fingerprint

sensor dies.

8. A device according to claim 7, wherein a ground contact is located between each pair of adjacent sensing array surfaces.

9. A device according to claim 7 or claim 8, wherein the ground contact is in the form of a grid.

10. A device according to any of claims 7 to 9, wherein the ground contact has a conducting surface which is raised above the surface of the sensing array surfaces.

11. A method of constructing a fingerprint image, the method comprising obtaining a number of fingerprint image portions from a finger of a user using a fingerprint sensing device according to any of claims 1 to 10, each image portion being obtained from a corresponding sensor die, calculating direction information at an edge of a first image portion corresponding to an edge of a first sensing array surface which is adjacent to but separated from an edge of a second sensing array surface, interpolating the direction information and pixel values at the edge of the first image portion to obtain the values of pixels between the edge of the first image portion and an edge of a second image portion corresponding to the edge of the second sensing array surface.

12. A method according to claim 11, further comprising calculating direction information at the edge of the second image portion and interpolating the direction information and the pixel values at the edges of the first and second image portions to obtain the values of pixels between the edges of the first and second image portions.

13. A method of constructing a fingerprint image, the method comprising obtaining a first set of fingerprint image portions from a finger of a user using a fingerprint sensing device according to any of claims 1 to 10, each image portion being obtained from a corresponding sensor die, obtaining a second set of fingerprint image portions from the fingerprint sensing device with the position of the finger on the sensing device offset from the position in which the first set of image portions was obtained, and comparing the first and the second sets of fingerprint image portions.

ABSTRACT

A FINGERPRINT SENSING DEVICE

A fingerprint sensing device (10) includes a number of fingerprint sensor dies (11). Each die (11) includes a sensing array surface (12). The dies (11) are arranged so that the sensing array surfaces (12) of the dies (11) define a device sensing surface.

Figure 1

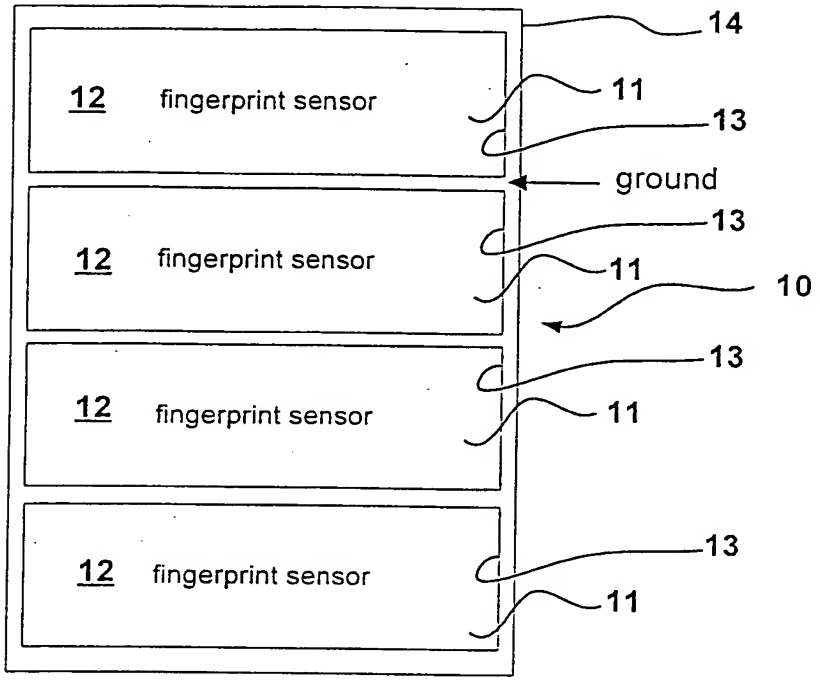

Figure 1

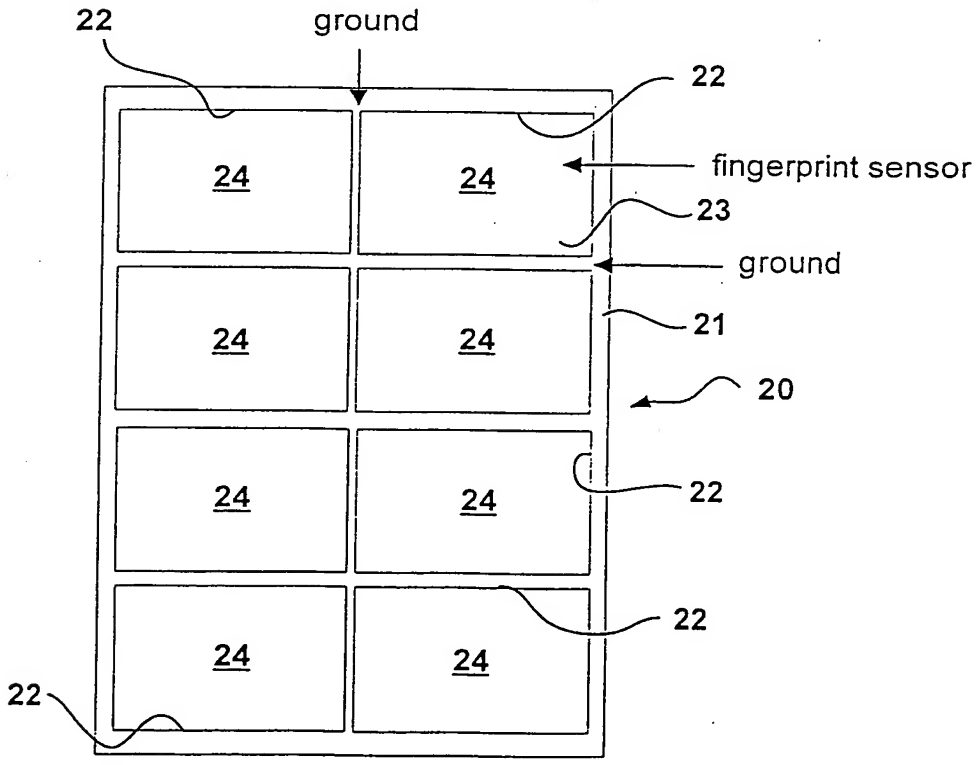

Figure 2

Fingerprint sensor array formed from a subset of smaller fingerprint sensors

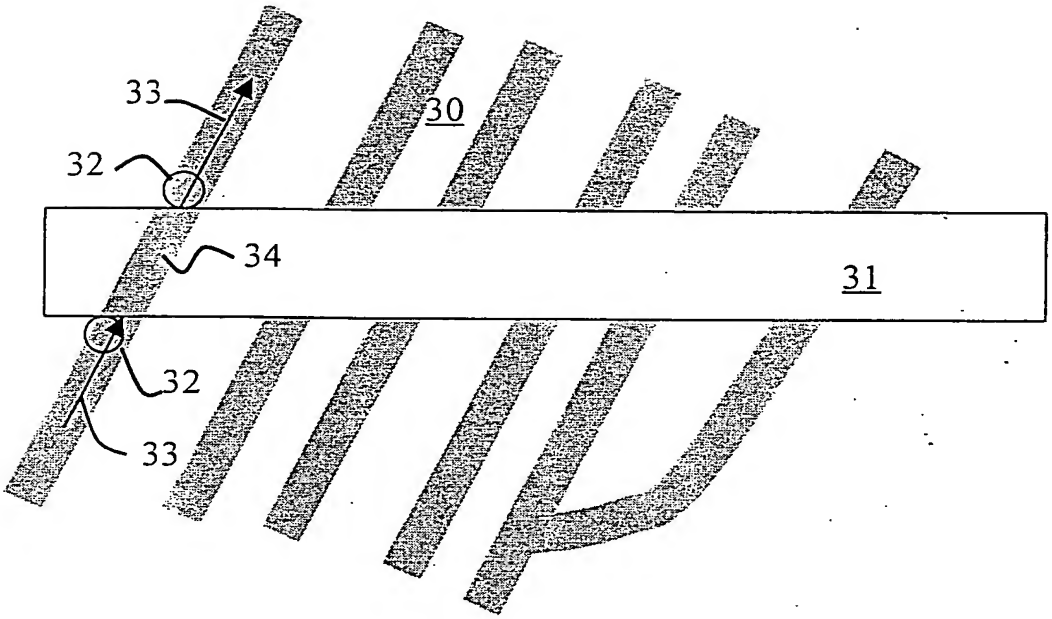

Figure 3.